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Spatio-temporal analysis of coastal and marine environments based on local remote sensing and photogrammetry

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Abstract: *In coastal and marine environments, physical and chemical quantities such as flow, wave, temperature, and substance are closely related to biological ones, but the integration of these data is still insufficient at present. As a powerful method for acquiring environmental information, local remote sensing technology is attracting attention now. In that method, it is necessary to develop highly accurate and efficient methods for image processing. The purpose of this study is to examine the photogrammetry method on the basis of observation data obtained from local remote sensing by ship and UAV. We adopted the Shape from Shading (SFS) algorithm to build 3D/4D wave surface models, and the Structure from Motion (SFM) algorithm was also used to make a 3D beach topography model. Such attempts are important for integrated evaluation of local remote sensing with spatio-temporal environmental information.*

Keywords: Local remote sensing; 3D/4D model; Shape from Shading (SFS); Structure from Motion (SFM); Coastal and marine environments

1. INTRODUCTION

The change of land use and the increase of energy consumption in urban areas, and serious environmental deterioration in living areas have been caused in association with the rapid development of society. In addition, though highly accurate observation data serve as the basis for advanced use of environmental information, such data are relatively difficult to acquire. Figure 1 shows a map of the concept in this study. In recent years, as important technologies working in collaboration with GPS and Internet, UAV (Unmanned Air Vehicles) [1] and IoT (Internet of Things) have been developed accordingly. These technologies also give great impacts on the fields of coastal and marine environments, and they will become increasingly important in the future so as to visualize and utilize environmental information for sustainable development in coastal regions.

In addition to numerical simulation, the local remote sensing technology which is capable of monitoring relatively large areas with high resolution is expected to progress in the fields of coastal and marine environments. Hence, observation technique by UAV like drone to extract environmental information from image data has been become important, and information science such as image processing, machine learning, and deep learning will be integrated with the local remote sensing technologies. Therefore, the importance of a new research field to be called Environmental Hydroinformatics[2], which treat the environment and information integrally, will increase greatly in the future.

Our research group have made a collaborative research with Fukuoka Prefecture's Fisheries Agency to obtain wave properties from digital camera image data on the sea surface. Moreover, we received image data of beach topography by using UAV. In this study, we used observation data of coastal and marine environments such as wave properties and beach topography. Figure 2 shows the ship used for taking wave images and the UAV we used in this study.

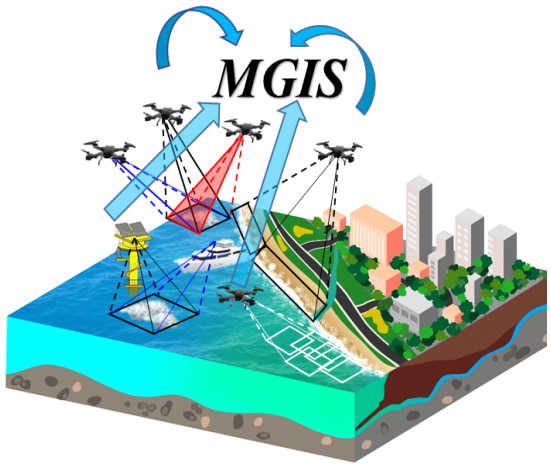

Fig. 1. Map of research concept

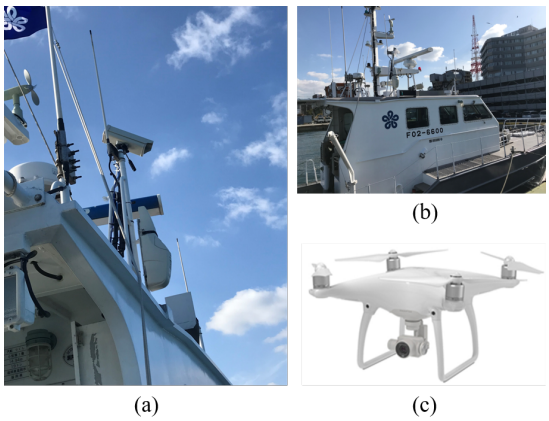

Fig. 2. Observation tools for local remote sensing
(a) Camera on ship (b) Ship: TSUKUSHI
(c) UAV: Phantom4

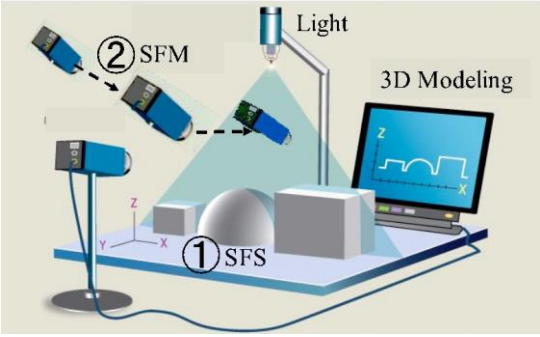

Fig. 3. Conceptual diagram of "SFX" measurements

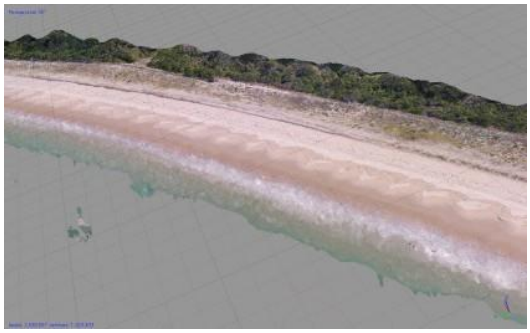

Fig. 4. 3D beach topography modeling by SFM

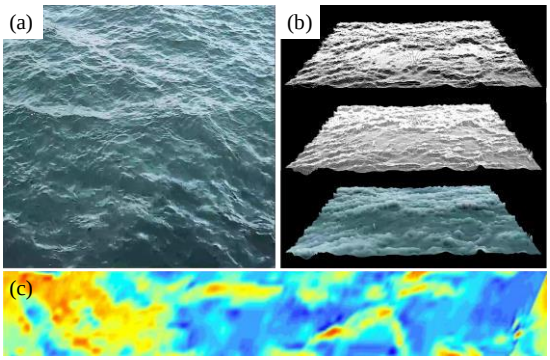

Fig. 5. 3D/4D wave modeling by SFS
(a) Original image data
(b) 3D wave model
(c) Wave height distribution

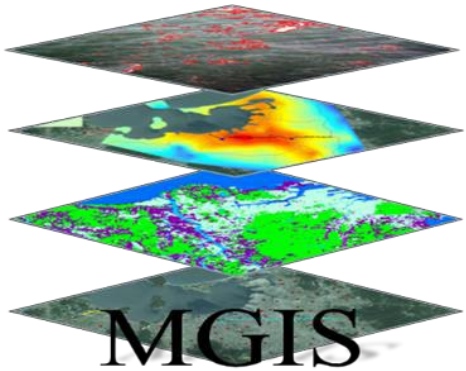

Fig. 6. Marine Geographic Information System

2. RESEARCH METHODS

With the continuous developments of computer vision and virtual reality, the three-dimensional reconstruction of image gradually becomes one of the significant research topics of computer science, and it plays an increasingly important role and function in many fields. At present, multiple reconstruction technologies have formed that are abled by a joint name – "Shape/Structure from X" technology and the X could be the sports, texture, profile, shadow and so on. In this study, we adopted the Shape from Shading (SFS) algorithm to build 3D/4D wave surface models[3], and the Structure from Motion (SFM) [4] algorithm was used to make a 3D beach topography model. Figure 3 displays the conceptual diagram of "SFX" measurements. In accordance with the light and shade variation of the object surface in the image, SFS algorithm recovers the relative heights of all points on the object surface which means to recover the object height in line with the grey information of the image surface to build the 3D model.

3. RESULTS AND DISCUSSION

The 3D beach model reconstructed in this study is shown in Fig. 4. In addition, Fig. 5 shows the 3D wave surface model and wave height distribution, but at this stage, the calibration of the wave height in the wave model has not been made. In the future research process, a new calibration method will be provided to quantify the wave height information in the model. The GNSS will be used to improve the accuracy of 3D topographic model of coastal beach environment.

Stated above, we have already made the modeling of the 3D/4D wave and the coastal beach topography. In order to make the calibration of 3D wave model and improve its accuracy, we will carry out laboratory wave experiments to get the quantitative relation between the wave model and the wave height distribution. As research targets for integrated evaluation of local remote sensing with spatio-temporal environmental information, image data of sea surface acquired by drone and offshore facilities will be utilized. And as Fig. 6 shows that we will also consider the extraction of environmental information through machine learning and deep learning, and integration technology based on MGIS[5].

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